ENVIRONMENTAL IMPACTS OF SHALE GAS EXPLOITATION

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ABSTRACT:

Due to ever increasing energy demands and depleting conventional reservoirs, world is focusing towards the exploitation of unconventional reservoirs with the help of advanced technology that has been developed over the period. Exploitation of shale is one such development among others that has recently been witnessed, although the exploitation of shale has posed certain environmental challenges that need to be known and properly addressed.

The technology that has been employed for the development of shale is hydraulic fracturing, horizontal drilling, multi fracking etc that are the most significant sources of environmental destruction along with some others. This has posed a significant challenge to the companies that are involved in these operations. Civil society is reacting sharply to the consequences of such operations and the effects they are going to generate on environment. Different environmental laws have been breached and due to which certain areas are banned for the shale hydraulic fracturing like New York, Vermont states etc in America. Different documentaries on the subject had been made like "Gas land by Josh fox" that certainly shows the level of concern it has generated among the civil society who is at stake.

Hence a comprehensive study has been performed on the potential threats on environment due to shale gas exploitation and what could be done to minimize such adverse effects. Some of the findings of the study are that the environmental threats may be reduced with the help of careful planning of operations that needs to be carried out and the employment of technology that has been developed specially for the minimization of adverse environmental aspects of shale exploitation. Further, there is a need of a further research into this matter to make it as environment-friendly as possible.

1. INTRODUCTION:

From the last decades, the oil and gas has been explored and produced through conventional resources as they are available, easy to develop and economical as well.

The oil and gas as a fuel is typically found in permeable formation like as sandstone, limestone etc. The oil or gas produced through conventional extraction method are becoming increasingly limited to meet the current market demand. Therefore, in order to meet the market demand, the world is moving from conventional to unconventional natural gas sources or alternative. The shale gas, coalbed methane, and tight gas are the common examples of unconventional natural gas sources.

In unconventional extraction, the gas is extracted from reservoir by alteration of reservoir characteristics like as porosity, permeability, fluid trapping mechanism etc or rock characteristic. The hydraulic fracturing is the technique that helps to alter the characteristics of reservoir and rock and enables gas to flow in the borehole.

Due to extensive amount of unconventional reservoirs present, world is focusing towards the development of shale reservoirs which has posed certain environmental hazards as well that needs to be addressed and controlled [1]. This study focused on many health risk and various environmental issues connected with the unconventional extraction methods i.e growth and development of high volume hydraulic fracturing.

2. Shale Gas Extraction

Two most importance technologies has been used to deliver the potential to unlock tighter shale gas formations.

These technologies are “Horizontal drilling” and “hydraulic fracturing”. Both technologies are used combined to extract gas from shale formation see Fig 1. [2].

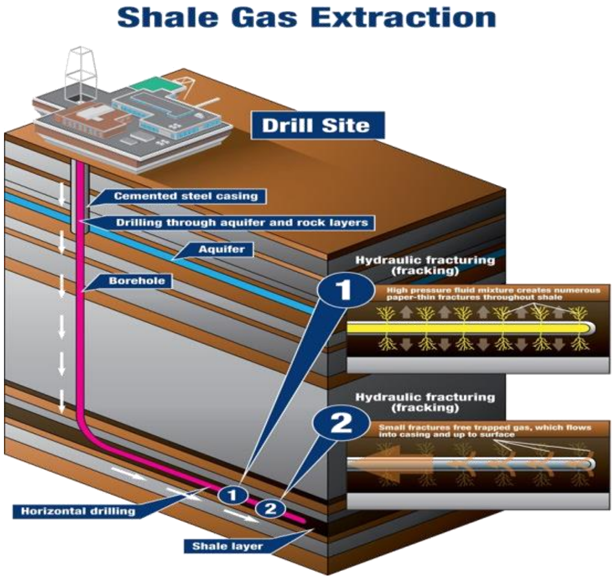

Fig. 1. Shale Gas Extraction process.

For shale gas extraction, the horizontal well is drilled which allows the well to pass through toward the hydrocarbon bearing rock seam, which may not be greater than 90m thick. Basically, this type of drilling has an advantage to maximize the contact area between the wellbore and formation. After that hydraulic fracturing or fracking to be done which may maximizes the well production i.e flow and volume of the produced gas.

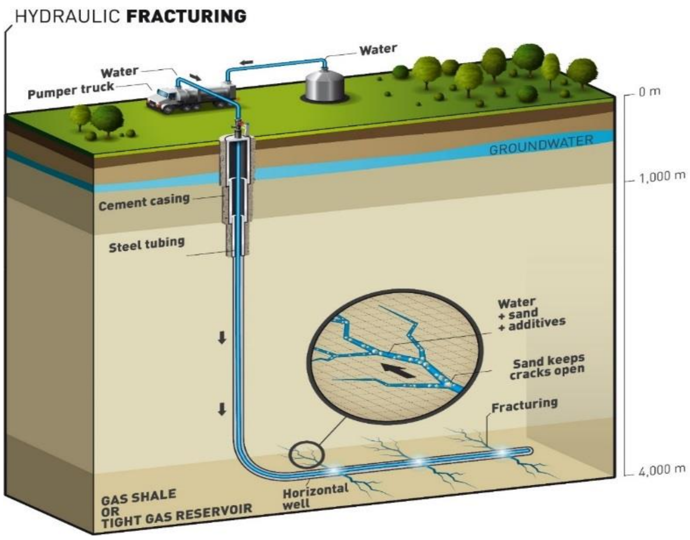

Fig. 2. Hydraulic fracturing process.

Well, stimulation technique such as hydraulic fracturing, acidizing can be used in the well bore to increase the permeability of the fluid and are implemented to extract the shale reserves. Hydraulic fracturing or fracking is helps to build a fractures in the rock bearing hydrocarbon formation[3]. The size of these fractures may as few 100 meters into the reservoir rock and commence at horizontal departure see Fig 2.

3. Water Usage

It is very difficult to create fractures in the well without water. Usually, two to five million gallons water required to complete each fracture job. Therefore, water is essential for fracturing job. In some case, the water can be used as recycled but the water recycle treatment process desires a major recession from the aquifer or other water resources [4].

Passage to plentiful water is critic to shale gas development and it directly effects on the sources of plenty water and therefore, secession must be managed. Nowadays, most of industry is working on this hazard and taken tremendous efforts as well in managing the water secession, water treatment and use the produced water as this reducing the water demands of shale gas drilling.

4. Environmental Hazards

The main environmental hazards associated with the shale gas extraction are defined as under:

4.1 Surface & grand water contamination

The high risk of water contamination has been seen at different steps of the well site preparation, fracking process, fluids flow toward the surface, and during well abandonment as well in surface and ground level.

The surface water contamination may be result of runoff and erosion during early site preparation. After runoff and erosion, most of silt particles are accumulated in surface waters and contaminants penetrating streams, water bodies, and groundwater. This is the common problem which has been seen in entire large-scale mining as well as activities of extraction[5].

In extraction activities especially unconventional gas extraction which carries a higher risk as it requires high-volume processes per installation and the risks increase with respect to multiple installations. Shale gas installations are expected to generate greater stormwater runoff, which could affect natural habitats through sediment build up, stream erosion, flooding, and water degradation.

This study considered the water contamination risks due to following reasons:

- Poor well design or poor casing structure.
- Well, kick or mechanical equipment failure.
- Movement of combustible natural gas towards the water storage/supplies.
- Geological conditions are inadequate.
- Inadequate planning and site preparation and management.

4.2 Air emissions

It is found from literature that the natural gas produced during the fracking operations can be bad for the atmosphere as compared with coal [6]. Because this natural gas discharge into the atmosphere. Further, study suggested that the emissions from shale gas are between 20-100% more than the coal through life cycle greenhouse gas (GHG) on a 20-year timeframe basis [7].

Most of natural gas industries are taken effort to reducing the methane emissions during shale gas operation along with emissions of carbon dioxide, sulphur dioxide, hydrogen sulphide from treating and other process of sour water for hydraulic fracture job. The emission produced from this fracking operations are harmful for the environment.

4.3 Land and Take

Some of the study shows that the land used in shale gas extraction has a significant risk of impacts because small size of land required for production stage while large size of land required for fracking process.

4.4 Noise pollution

There are many sources of noise in shale gas extraction i.e during excavation, installation and drilling,

generator, process and transport etc and its level varies from stage to stage i.e preparation and production cycle.

4.5 Bioversity Impacts

The effect of biodiversity on unconventional gas extraction has seen and it may causes of degradation or splitting up or complete removal of a habitat as a result of site construction or excessive water absorption etc.

Other affect biodiversity occurs due to the operations of well drilling through noise, traffic and site management and hydraulic fracturing through sediment runoff, waste water, and contamination.

4.6 Traffic

Movements of truck is initially very high due to site development but these movements can be reduced by temporary setup i.e use of pipelines for water supply, drainage etc. The movements of truck may also be affecting on road damage, road safety issues, and other related infrastructure. The risk is may also increase as traffic increase due to spillages and accidents involving hazardous materials.

4.7 Visual Impacts

The effect of visual is to be considered as low during well-pad site identification and preparation. The risk of visual impacts connected with fracking is little bit important, with the essential diversity to the landscape in here of little bit visually invasive appearance.

4.8 Seismicity

The effect of seismic associated with fracking process is minor as up to 3 magnitude on the earthquake magnitude scale has been used and this would not be disturb to the public and undetectable as well. Therefore, the risk of this hazard is low [8].

The summary of risk level at various stages of field development o individual site and Cumulative are shown in table.1 & 2.

Table. 4.1. Level of risk at various stages of field development (Individual Site).

Aspects of Environmental hazards		**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**
		Site starts- up	Well design	Fracturing operations	Well Completion	Production	Well abandonment (Pre and post)	Overall rating
Water contamination	Ground	N.A	Low	Moderate-High	High	Moderate-High	N.C	High
	Surface	Low	Moderate	Moderate-High	High	Low	N.A	High
Resources of Water		N.A	N.A	Moderate	N.A	Moderate	N.A	Moderate
Air impact		Low	Moderate	Moderate	Moderate	Moderate	Low	Moderate
Land and take impact		Moderate	N.A	N.A	N.A	Moderate	N.C	Moderate
Biodiversity impact		N.C	Low	Low	Low	Moderate	N.C	Moderate

Noise impact	Low	Moderate	Moderate	N.C	Low	N.A	Moderate-High
Visual Impact	Low	Low	Low	N.A	Low	Low-Moderate	Low-Moderate
Seismicity impact	N.A	N.A	Low	Low	N.A	N.A	Low
Traffic impact	Low	Low	Moderate	Low	Low	N.A	Moderate

Table. 4.2. Level of risk at various stages of field development (Cumulative).

Aspects of Environmental hazards		**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**
		Site starts- up	Well design	Fracturing operations	Well Completion	Production	Well abandonment (Pre and post)	Overall rating across all phases
Water contamination	Ground	N.A	Low	Moderate-High	High	High	N.C	High
	Surface	Moderate	Moderate	Moderate-High	High	Moderate	N.A	High
Resources of Water		N.A	N.A	High	N.A	High	N.A	High
Air impact		Low	High	High	High	High	Low	High
Land and take impact		Very-High	N.A	N.A	N.A	High	N.C	High
Biodiversity impact		N.C	Low	Moderate	Moderate	High	N.C	High
Noise impact		Low	High	Moderate	N.C	Low	N.A	High
Visual Impact		Moderate	Moderate	Moderate	N.A	Low	Low-Moderate	Moderate
Seismicity impact		N.A	N.A	Low	Low	N.A	N.A	Low
Traffic impact		High	High	High	Moderate	Low	N.A	High

Note:

- Not applicable (N.A): Impact not relevant to this stage of development.
- Not classifiable (N.C): Insufficient information available for the significance of this impact to be assessed.

5. Control

5.1 Fracture Monitoring

The effects of fracking can be control through monitoring the fracturing design, process, treatment, and analysis. The monitoring technologies can be used for fracking treatment such as tiltmeter measurements and microseismic fracture mapping [9]. These both technologies are helps to map fracking location orientation and depth.

Micro-seismic is the monitoring technology in which seismic waves are generated during the fracking job and then monitor the generated fractures. This type of monitoring help to engineers by providing the capability to oversee the resource via brilliant placing of additional wells to yield benefits of understanding the subsurface conditions and its behavior and may also be expected fracture results in newly wells [10].

5.2 Change in Standard

The effects of fracking may also be controlled through change in standard like as "Green" or "Reduced Emissions Completions," in which both gas and liquid hydrocarbons are abstracted from flow back, would need to be occupied during completions and recompletions of fracking in gas wells.

The following change in standard may be used to reduce the effects on fracking operation [11]:

- Use of compressors for natural gas flow through pipelines.
- Centrifugal units is to be equipped with dry seal systems.
- Uses of pneumatic controllers during all process.
- Uses of condensate and crude oil storage tanks for reduction in VOC emissions.

6. Conclusion

- It is observed in this study that the risk is high on unconventional extraction method as compared with conventional but can be reduce by reducing the effect which affecting on unconventional extraction method.
- Above study shows that there are many potential threats on environment due to shale gas exploitation and could be minimize by careful planning of operation, proper monitoring, and control system.
- Environment-friendly methods can be adopted during fracking operation for success of the project.

Recommendations

From this study, it is recommended that:

- Overview on environment threat or potential risks should be considered before commence of any project.
- Adopting effective technologies for reducing the adverse effects especially in those areas where sensitivity is high related to the biodiversity, community etc.
- Measures and approaches to reduce land disturbance and land-take, pressure on biodiversity, noise (during drilling, fracturing, and completion), traffic movements, risk of ground and surface water Contamination.

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